MULTIPLE CHOICE (3 points each)

1) How many single covalent bonds must a silicon atom form to have a complete octet in its valence shell?
   A) 4   B) 3   C) 1   D) 2   E) 0

2) What is the maximum number double bonds that a carbon atom can form?
   A) 1   B) 4   C) 3   D) 2   E) 0

3) Of the atoms below, __________ is the least electronegative.
   A) Rb   B) Si   C) F   D) Ca   E) Cl

4) Given the electronegativities below, which covalent single bond is most polar?
   Element: H C N O
   Electronegativity: 2.1 2.5 3.0 3.5

5) Which of the following names is/are correct for the compound TiO$_2$?
   A) titanium oxide   B) titanium oxide and titanium (IV) dioxide
   C) titanium (II) oxide   D) titanium dioxide and titanium (IV) oxide
   E) titanium (IV) dioxide

6) The Lewis structure of N$_2$H$_2$ shows __________.
   A) each hydrogen has one nonbonding electron pair
   B) a nitrogen-nitrogen triple bond
   C) each nitrogen has one nonbinding electron pair
   D) each nitrogen has two nonbinding electron pairs
   E) a nitrogen-nitrogen double bond

7) In the Lewis structure of ClF, the formal charge on Cl is __________ and the formal charge on F is __________.
   A) 0, 0   B) -1, -1   C) 0, -1   D) +1, -1   E) -1, +1

8) How many resonance forms can be drawn for CO$_3^{2-}$ (carbon is the central atom)?
   A) 0   B) 2   C) 3   D) 4   E) 1

9) The molecular geometry of __________ is square planar.
   A) ICl$_3$   B) CCl$_4$   C) XeF$_2$   D) PH$_3$   E) XeF$_4$

10) The molecular geometry of the SF$_2$ molecule is __________.
    A) trigonal planar   B) bent
    C) linear   D) octahedral
    E) tetrahedral
11) Three monosulfur fluorides are observed: SF\textsubscript{2}, SF\textsubscript{4}, SF\textsubscript{6}. Of these, ________ is/are polar.
   A) SF\textsubscript{6} only
   B) SF\textsubscript{2} and SF\textsubscript{4} only
   C) SF\textsubscript{2} only
   D) SF\textsubscript{4} only
   E) SF\textsubscript{2}, SF\textsubscript{4}, and SF\textsubscript{6}

12) Of the following, the central atom is sp\textsuperscript{3}d\textsuperscript{2} hybridized only in ________.
   A) BeF\textsubscript{2}
   B) PCl\textsubscript{5}
   C) Br\textsubscript{3}
   D) XeF\textsubscript{4}
   E) PH\textsubscript{3}

13) A typical triple bond ________.
   A) is longer than a single bond
   B) consists of one sigma bond and two pi bonds
   C) consists of two sigma bonds and one pi bond
   D) consists of three shared electrons
   E) consists of six shared electron pairs

14) According to MO theory, overlap of two s atomic orbitals produces ________.
   A) two bonding molecular orbitals and two antibonding molecular orbitals
   B) one bonding molecular orbital and one hybrid orbital
   C) two bonding molecular orbitals and one antibonding molecular orbital
   D) one bonding molecular orbital and one antibonding molecular orbital
   E) two bonding molecular orbitals

15) An antibonding MO ________ the corresponding bonding MO.
   A) is always degenerate with
   B) is always higher in energy than
   C) can accommodate more electrons than
   D) can accommodate fewer electrons than
   E) is always lower in energy than

16) According to valence bond theory, which orbitals overlap in the formation of the bond in HBr?
   A) 2s on H and 4p on Br
   B) 1s on H and 4p on Br
   C) 1s on H and 4s on Br
   D) 1s on H and 3p on Br
   E) 2s on H and 3p on Br

17) Of the following, ________ is a correct statement of Boyle's law.
   A) n/P = constant
   B) P/V = constant
   C) PV = constant
   D) V/T = constant
   E) V/P = constant

18) A sample of a gas (5.0 mol) at 1.0 atm is expanded at constant temperature from 10 L to 15 L. The final pressure is ________ atm.
   A) 7.5
   B) 15
   C) 0.67
   D) 3.3
   E) 1.5

19) Of the following, ________ is a valid statement of Charles' law.
   A) P/T = constant
   B) V/T = constant
   C) V = constant multiply P
   D) PV = constant
   E) V = constant multiply n
20) Which one of the following is a valid statement of Avogadro's law?
   A) PV = constant   B) P/T = constant
   C) V = constant multiply P   D) V/n = constant
   E) V/T = constant

21) A gas originally at 27°C and 1.00 atm pressure in a 3.9 L flask is cooled at constant pressure until
   the temperature is 11°C. The new volume of the gas is _________ L.
   A) 0.27   B) 0.24   C) 3.9   D) 4.1   E) 3.7

22) The amount of gas that occupies 60.82 L at 31°C and 367 mmHg is _________ mol.
   A) 1.18   B) 0.120   C) 0.850   D) 894   E) 11.6

23) A flask contains a mixture of He and Ne at a total pressure of 2.6 atm. There are 2.0 mol of He and
   5.0 mol of Ne in the flask. The partial pressure of He is _________ atm.
   A) 1.04   B) 1.86   C) 0.74   D) 6.5   E) 9.1

24) Which of the following is not part of the kinetic-molecular theory?
   A) Collisions between gas molecules do not result in the loss of energy.
   B) Attractive and repulsive forces between gas molecules are negligible.
   C) Atoms are neither created nor destroyed by ordinary chemical reactions.
   D) The volume occupied by all of the gas molecules in a container is negligible compared to the
      volume of the container.
   E) Gases consist of molecules in continuous, random motion.

25) An ideal gas differs from a real gas in that the molecules of an ideal gas _________.
   A) have an average molecular mass
   B) have no kinetic energy
   C) have a molecular weight of zero
   D) have no attraction for one another
(5 points) Calculate the $\Delta H^o_{\text{rxn}}$ for the following reaction using the following bond enthalpies:

$$\text{N} = \text{N} + 2 \text{HCl} \rightarrow 2 \text{H} = \text{N} + \text{Cl} = \text{Cl}$$

<table>
<thead>
<tr>
<th>Substance</th>
<th>Bond Enthalpy (kJ/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-N</td>
<td>391</td>
</tr>
<tr>
<td>N-N</td>
<td>163</td>
</tr>
<tr>
<td>Cl-Cl</td>
<td>242</td>
</tr>
<tr>
<td>N-Cl</td>
<td>200</td>
</tr>
</tbody>
</table>

$\Delta H^o_{\text{rxn}} = \text{[bonds broken]} - \text{[bonds formed]}$

$\Delta H^o_{\text{rxn}} = [1(\text{N-N}) + 1(\text{Cl-Cl})] - [2(\text{N-Cl})]$

$\Delta H^o_{\text{rxn}} = [(1\text{mol}(163\text{kJ/mol})) + (1\text{mol}(242\text{kJ/mol}))] - [2\text{mol}(200\text{kJ/mol})]$

$\Delta H^o_{\text{rxn}} = 5\text{kJ}$

(10 points) Write the Lewis structures for following molecules:

- SnCl$_2$
  $$\text{SnCl}_2$$

- CH$_3^+$
  $$\text{CH}_3^+$$

- PCl$_5$
  $$\text{PCl}_5$$
(10 points) The metabolic oxidation of glucose, $\text{C}_6\text{H}_{12}\text{O}_6$, in our bodies produces $\text{CO}_2$, which is expelled from our lungs as a gas:

$$\text{C}_6\text{H}_{12}\text{O}_6(\text{aq}) + 6 \text{O}_2(\text{g}) \rightarrow 6 \text{CO}_2(\text{g}) + 6 \text{H}_2\text{O}(\text{l})$$

Calculate the volume of dry $\text{CO}_2$ produced at body temperature ($37^\circ\text{C}$) and 0.970 atm when 24.5 g of glucose is consumed in this reaction.

$$\text{moles glucose} = \frac{24.5 \text{g}}{180.12 \text{g/mol}} = 0.136 \text{mol}$$

$$\frac{6 \text{CO}_2}{1 \text{glucose}} = \frac{x}{0.136 \text{mol}}$$

$$x = \text{moles CO}_2 = 0.816 \text{mol}$$

*now use the ideal gas law*

$$PV = nRT$$

$$P = 0.970 \text{ atm}$$

$$V = ?$$

$$n = 0.816 \text{ mol}$$

$$R = 0.08206 \text{L(atm)(mol}^{-1})\text{K}^{-1}$$

$$T = 37 + 273 = 310 \text{ K}$$

$$0.970 \text{ atm}(V) = 0.816 \text{ mol}(0.08206)(310 \text{ K})$$

$$V = 21.4 \text{ L}$$
MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) A
2) D
3) A
4) E
5) D
6) C
7) A
8) C
9) E
10) B
11) B
12) D
13) B
14) D
15) B
16) B
17) C
18) C
19) B
20) D
21) E
22) A
23) C
24) C
25) D